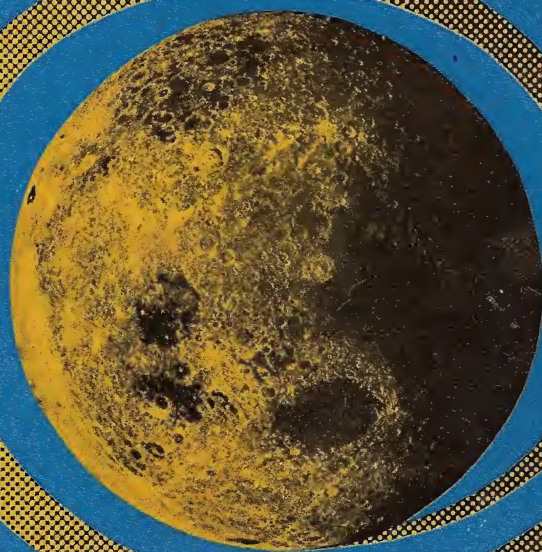


FIFTY CENTS ®

JULY 18, 1969

TIME



TO THE MOON
SPECIAL SUPPLEMENT

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MICHAEL CA 95608

MOON SUPPLEMENT

A NEW

MAN's eternal quest for the new and the unknown has led him to the highest mountains and the deepest ocean trenches, the most impenetrable jungles and the most forbidding deserts. This week it promises to lead him across the vacuum of space to another world. At Cape Kennedy, a 363-ft. moon rocket stood ready to launch three American astronauts on man's first attempt to set foot on the surface of another celestial body. If the bold attempt is successful, the journey will be remembered as long as the human race endures. It will open a new age of exploration, one that may ultimately reach to the outer limits of the solar system and even to the stars beyond.

Up to the last moment, it was possible that the failure of a single tiny device among the 15 million individual parts of Apollo 11 might cause delay on the pad or more serious consequences in space. Up to the last moment, too, complaints were being voiced about misspent money and misguided motives. But not even the skeptics could ignore or entirely downgrade so transcendent an event—one of those shining moments in history when man rises above himself toward greatness.

Forbidding Enough

Like Christopher Columbus and the other explorers who set out in search of new worlds, the Apollo 11 astronauts face experiences never before encountered by men. They are cool, pragmatic technicians, superbly trained for their flight and thoroughly familiar with their spacecraft. But they will be attempting the first descent to the moon, the first exploration of its surface, the first lift-off back into space. It is not unlikely, then, that beneath their composed exteriors, they share some of the doubts and even fears felt by their predecessors.

Spanish-born Historian and Philosopher Salvador de Madariaga, who has written extensively about the voyages of Columbus, addressed himself at TIME's request to the deeper meaning of explorations, past and present.

"From the very first days, when man sought to master the unknown by finding out what the valley next to his was like, until today, when the unknown is the solar system, man has had to conquer the fear of the dangers which the unknown conceals not only as they are but as he fancies them," writes De Madariaga. "The companions of Bartholomeu Diaz had to conquer the fear that the ocean at and beyond the equator might boil or drop into a cosmic precipice; the companions of Columbus feared griffins, sirens, men with tails or with their heads screwed to their navels. Our astronauts' imagination is more disciplined by knowledge, but even in our day, when fancy and imagination have been disposed of, what remains is forbidding enough. Yet man is not daunted. These undaunted men are the true creators of history, those thanks to whom history is not a blind chain of facts but a clear-sighted sequence of acts—events that were ideas before they happened. It is from men who act on nature, and do not merely suffer to be acted upon by her, that history flows."

A Better Launching Pad

If there are similarities between the mission of Apollo 11 and other historical ventures of exploration and discovery, there are also vast differences. When Columbus landed in the New World, he had a handful of bewildered Indians for an audience, and Queen Isabella did not get the news until six months afterward. In more recent times, the world did not learn of the arrival of Peary's lonely band at the North Pole in 1909 until five months after the event. Yet when—and if—the first astronaut sets foot on the moon, he will be observed by a worldwide audience numbering hundreds of millions. Even more remarkable, only 1.3 seconds, the time it takes for radio waves to travel between moon and earth, will elapse between the actual event and its appearance on television screens.



ASTRONAUT ARMSTRONG WITH LUNAR MODULE

WORLD

The vehicles that will take Astronauts Neil Armstrong, Edwin Aldrin and Michael Collins on their epic journey have been aptly named. The lunar module that will land on the moon's surface has been christened *Eagle* because, Armstrong said, it is "representative of the flight and the nation's hope." The command module that will carry the astronauts back to earth has been dubbed *Columbia*, a close approximation of *Columbiad*, the name that Jules Verne gave to his lunar craft in his 1865 novel, *From the Earth to the Moon*. Prophetically, Verne launched *Columbiad* from a site in Florida and brought it down in the Pacific Ocean, where it was picked up by a U.S. naval vessel.

Ideally, the nationality of the first men to land on an extra-terrestrial body should be of negligible importance. But the fact is that it will be seen by many as a specifically American victory in a hard-fought race whose outcome has not always been so clear. After Sputnik, when Soviet space firsts and U.S. space failures were occurring with disheartening regularity, a Soviet official boasted: "The space programs of the United States and the Soviet Union have demonstrated for all the world to see that socialism is a better launching pad than capitalism."

Now, the Soviets seem to be conceding the race to the moon. Congratulations from Russian officials and astronauts have become progressively more cordial after each new U.S. space victory, and Apollo 8 Astronaut Frank Borman received one of the warmest welcomes ever accorded an American during his triumphant tour of Russia. By no means, however, have the Russians dropped out entirely. Just before the scheduled Apollo 11 shot, the Russians launched an unmanned spaceship toward the moon—in an obvious attempt to win some attention away from the U.S. Actually, some U.S. space officials believe that Moscow has decided to leapfrog the moon and head for the planets.

Out of the Cradle

No matter who takes the lead in space, it seems certain that man will continue to move outward in the universe—driven by the same force that once sent him across untracked wastelands and uncharted seas. In past ages, spices and gold tempted man to explore unknown regions, but they were far from the only lures. There was always something else that drew him, something less tangible—a thirst for adventure, for knowledge, and above all, for mastery of his world. The same impulse now compels him to reach for the moon, the planets and the stars beyond. As the Russian space theoretician Konstantin Tsiolkovsky once wrote: "The earth is the cradle of the mind, but you cannot live in a cradle forever."

To be sure, man has done much to despoil his cradle, and at this anguished moment in U.S. history there is some legitimacy to complaints that the billions of dollars being devoted to space might be better spent on earth. The poor cannot be blamed for being indifferent or even bitter when they watch the shining and vastly expensive rocket travel into the sky on a mission that does not improve their immediate future. The prophets who denounce ugliness and injustice on earth similarly have a case against the space program. But the case is shortsighted. For the ultimate benefits of space exploration, as of the earlier journeys of discovery, lie in what man discovers about himself and how he changes his own life. The discovery of the new world of America totally altered Europe; so the discovery of the new world of space may change modern civilization and provide what De Madariaga calls a new light "so that our supreme aim may become clearer: the intelligent organization of life on the planet."

Sooner rather than later, man will have to take heed of that supreme aim, and begin devoting immense energy and resources to solving the increasingly complex problems he has created on his own planet. This week, however, he can be pardoned if his eye is on the heavens, not the earth.

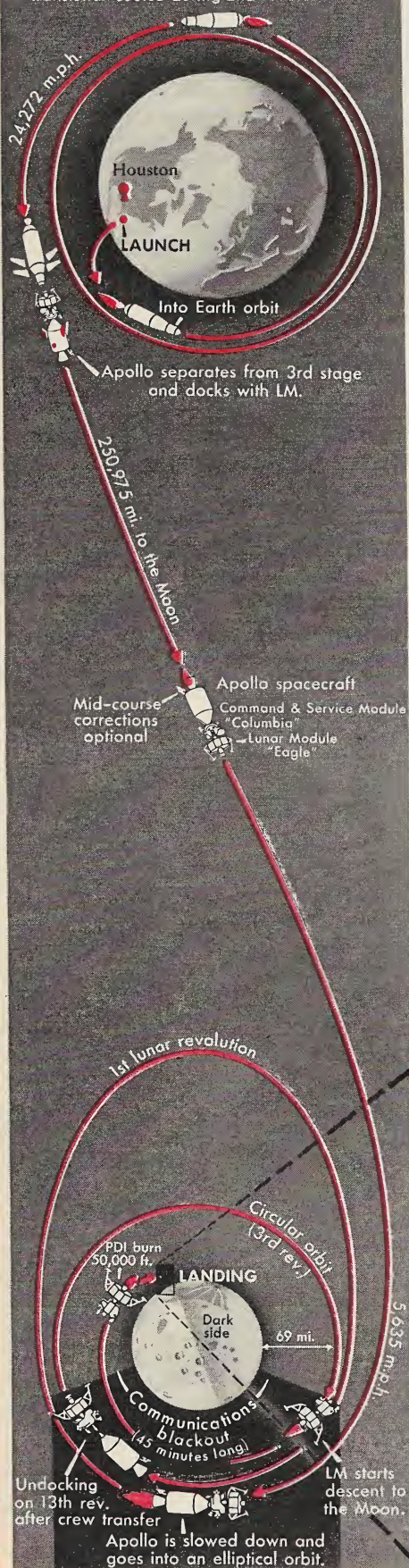


CHRISTOPHER COLUMBUS ABOARD THE "SANTA MARIA"

TO THE MOON

LAUNCH: 9:32 A.M., E.D.T., JULY 16

Saturn's 3rd stage fires Apollo onto translunar course during 2nd revolution.



FLIGHT PLAN

FOR the first four days of their climactic mission, Astronauts Armstrong, Aldrin and Collins will follow closely the space route taken by Apollo 10 in May. Until the lunar module swoops to within 50,000 ft. of the moon, the Apollo 11 crew will face familiar challenges and risks. A minor malfunction could turn the flight into a simple earth-orbital mission or a quick loop around the moon. A more calamitous equipment failure could cause Apollo 11 to crash into the moon or leave the craft stranded in lunar orbit. But from the moment that Houston radios, "We are go for PDI [powered descent initiation]," Armstrong and Aldrin will be blazing a new trail. They will have begun man's first descent to the surface of another celestial body.

Tracking landmarks through the front windows of the lunar module (LM) as it flies face down, the astronauts will fire their descent engine when the craft is 50,000 ft. above the moon and 300 miles east of the planned landing site in the Sea of Tranquility. Its forward velocity slowed by the blasting engine, the LM will begin dropping closer to the lunar surface. At 39,250 ft., the craft will begin rolling into a face-up position, pitching into an upright attitude at the same time. Twelve minutes later, its rate of fall slowed from 5,660 ft. per sec. to between 3 f.p.s. and 5 f.p.s., the LM will touch down. The first contact with lunar soil will be made by 5-ft. probes dangling from the LM's footpads. When the probes brush the surface, two lights the size of half-dollars will begin flashing in the LM under the white-lettered words, "lunar contact," and Armstrong will cut off the engine. The LM will then drop the last few feet to the surface, touching down at 4:19 p.m. (E.D.T.) on Sunday.

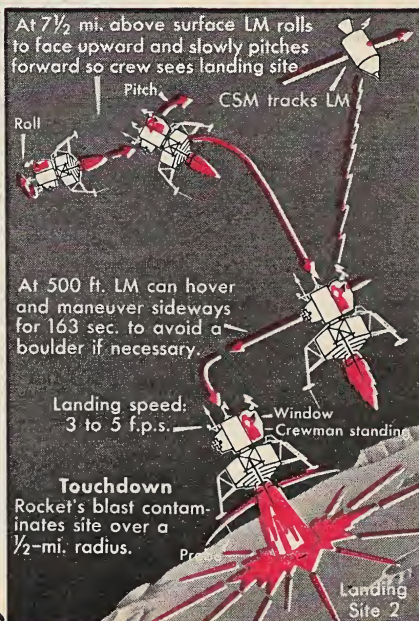
At this point, Astronauts Armstrong and Aldrin will hastily check out the LM for any damage suffered in the landing. Should they discover any serious problems, such as leaking fuel or falling pressure in the cabin, they will abort the mission, blasting off immediately to rejoin Collins in the orbiting command module. If all is well, they will have a brief snack, sleep for four hours and eat a leisurely dinner. Only then will they struggle into their bulky space suits, visored helmets, boots and gloves. With their Portable Life Support System (PLSS) backpacks, which supply air conditioning and enough oxygen for four hours, each will be encased in 183 lbs. of equipment. But under weak lunar gravity (one-sixth the earth's), the total weight of each fully burdened astronaut will be only about 60 lbs.

Left Foot Forward

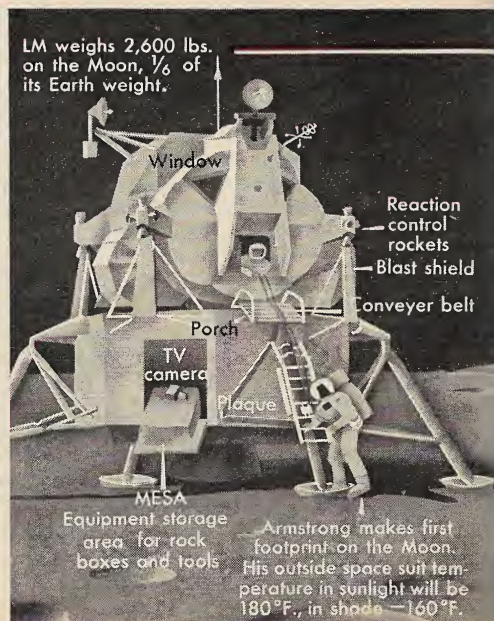
Some ten hours after the landing, Armstrong will begin EVA (extra-vehicular activity), backing feet-first out of the hatch, on his belly. On the LM's "porch," he will pull a ring that opens a storage area and exposes a mounted TV camera, which will relay to audiences on earth a view of his awkward progress down the LM's ladder. At the bottom, Armstrong will place his right foot in the bowl-shaped footpad and—by 2:22 a.m. Monday, if he is on schedule—plant his left foot firmly on lunar soil.

Armstrong will first test his ability to walk and maneuver in his bulky suit. Immediately after, he will scoop up some lunar material in a sample bag at the end of a long, telescoping handle and place the bag in his pant-leg pocket. Thus, even if the mission had to be aborted at that moment, Apollo 11 could

LUNAR LANDING



MEN ON



4:19 P.M., JULY 20

EVA: 2:12 A.M., JULY 21

OF APOLLO 11

bring at least some moon material back to earth.

About 25 minutes after Armstrong emerges from the LM hatch, Astronaut Aldrin will pass an electrically powered Hasselblad still camera down a nylon conveyor (similar to a clothesline on pulleys), and then back down the ladder himself. The astronauts will move next to the opened storage area, called MESA, for Modularized Equipment Storage Assembly. Armstrong will detach the TV camera and place it on a stand about 30 ft. from the LM to provide a panoramic view of the surface activities. While Aldrin is setting up a solar wind experiment, consisting of a 1-ft. by 4-ft. aluminum-foil strip designed to capture particles streaming in from the sun, Armstrong will scoop up another 60 lbs. of lunar rocks and soil and place them in an aluminum sample box.

From an equipment bay on the other side of the LM, the busy spacemen will remove EASEP (for Early Apollo Scientific Experiments Payload). They will set up one part of the package—a laser-beam reflector—some 70 ft. from the LM. The other experiment, a seismometer for measuring moonquakes and meteor impacts, will be placed 10 ft. farther away. Both will be left on the moon for the benefit of earthbound scientists (see following section).

Exploring the area within 100 ft. of the LM, Aldrin will scoop up scientifically interesting rocks, while Armstrong photographs each site and takes notes about the specimens. Armstrong will also thrust a core sampler as far as 12 in. into the soil to collect subsurface samples uncontaminated by the exhaust from the LM's descent engine. Up to 60 lbs. of documented rocks will then be placed in a second aluminum sam-

ple box, along with core samples and the aluminum solar particle collector, and sealed.

Before they depart, the astronauts will leave behind three items of symbolic import: a 3-ft. by 5-ft. U.S. flag stiffened with thin wire so that it will appear to be flying on the windless surface of the moon; a silicon disk bearing good-will messages for posterity from world leaders, including President Tito, Pope Paul and Queen Elizabeth; and a metal plaque bearing the names not only of the three astronauts, but also of President Richard M. Nixon, a fact that has stirred some criticism.

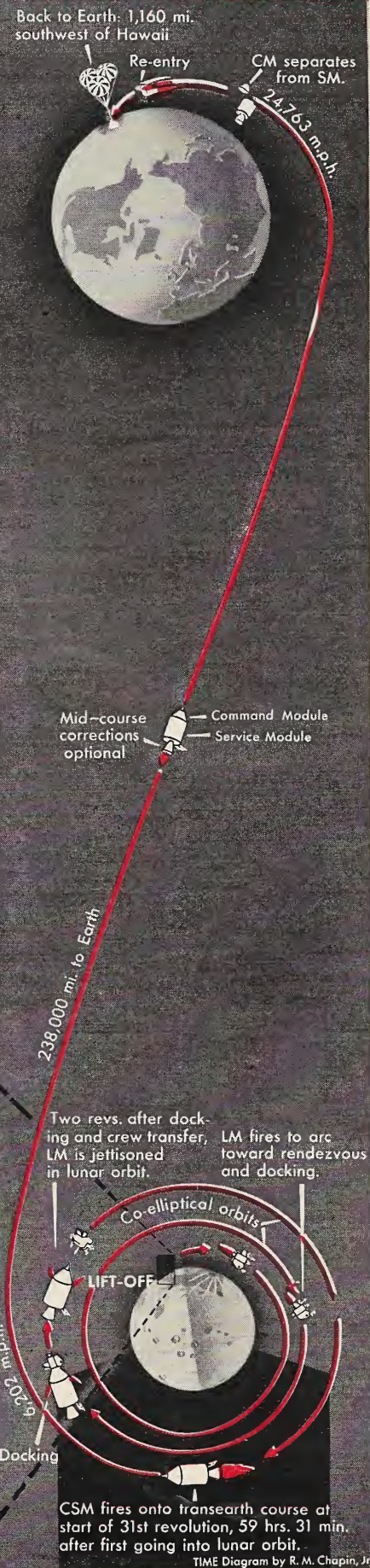
Four-Legged Launch Pad

After Aldrin has climbed back aboard the LM, Armstrong will send the sample boxes up the nylon conveyor and re-enter the spacecraft, about 2½ hours after he first emerged. The astronauts will then toss their PLSS units, overshoes and a camera out of the spacecraft to reduce the possibility of bringing back equipment contaminated by any lunar organisms that might exist.

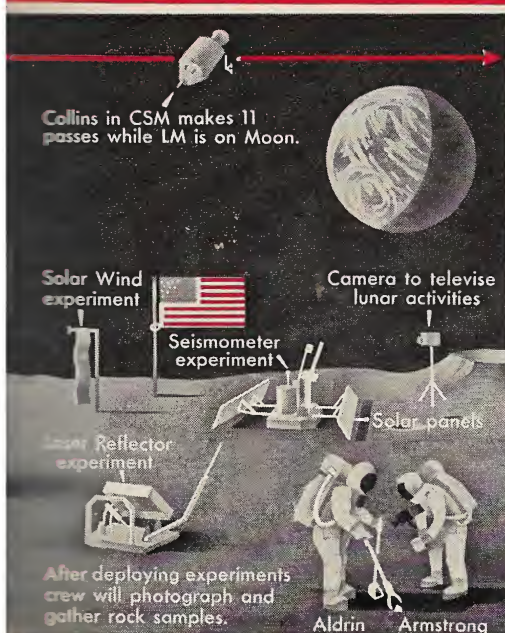
At 1:55 p.m. Monday, after another 4-hr. sleep period sandwiched between two meals, Armstrong and Aldrin will fire the LM's ascent engine, using the four-legged descent stage as a launch pad. If all goes well, they will rendezvous with Collins and transfer to the command module, taking their precious rocks with them in sealed boxes and leaving the LM in orbit around the moon. From that point on, they will again follow the path of Apollo 10. After firing themselves into an earth-bound trajectory, they will splash down in the Pacific Ocean some 1,160 miles southwest of Hawaii just before 1 p.m. (E.D.T.) on Thursday, July 24, their places in history assured.

RETURN TO EARTH

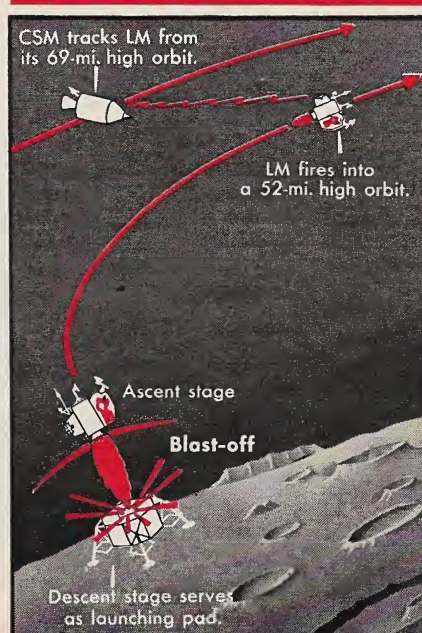
SPLASHDOWN: 12:51 P.M., JULY 24



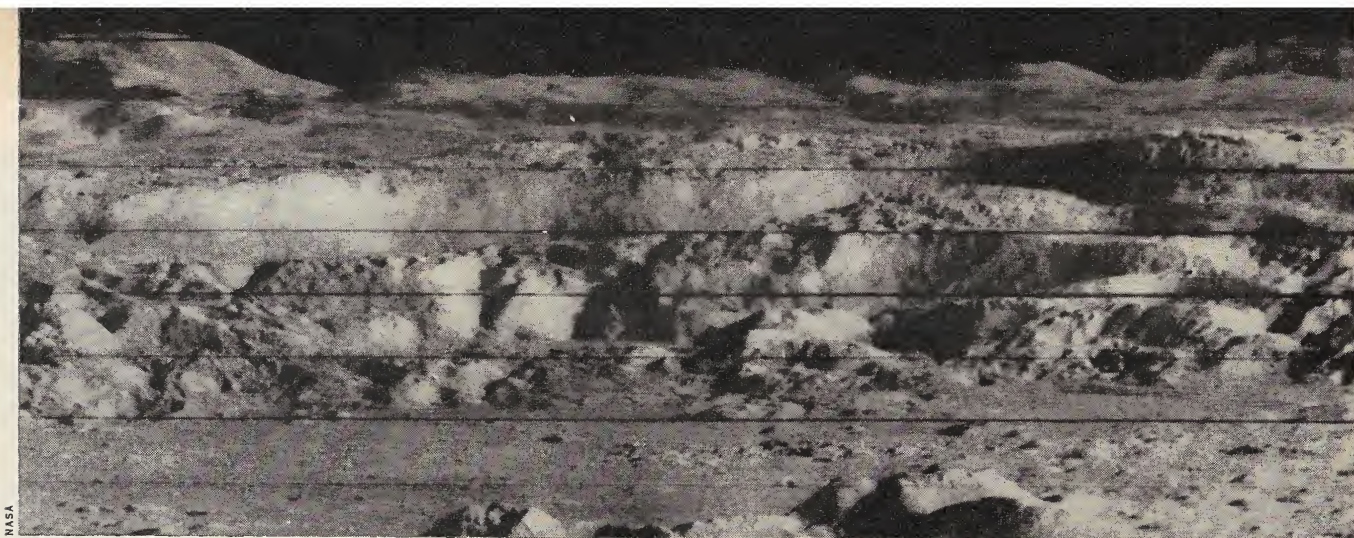
THE MOON



LUNAR LIFT-OFF



1:55 P.M., JULY 21



THE GREAT CRATER COPERNICUS (CENTER) PHOTOGRAPHED FROM LUNAR ORBITER 2

SECRETS TO BE FOUND

The moon is a Rosetta Stone of the planets.

—Robert Jastrow

UNCORRUPTED by the swirling gases of an atmosphere, unworn by the erosive pounding of wind and water, the moon has its history written plainly on its face. Geologically, its past and its present are as one, and clues to the events of billions of years are strewn across its surface with tantalizing clarity.

In the past five years, man has used the sophisticated instruments of the space age to learn more about the moon than he did during the 360 years that followed Galileo's pioneering look at the lunar surface through a telescope in 1609. Unmanned spacecraft have crashed into the moon, orbited it, measured it, and photographed it from every conceivable angle, giving man his first view of the lunar far side. Ingenious soft-landing spacecraft have dug into its soil and even chemically analyzed it by remote control.

Yet despite the recent heady accomplishments, the major questions about the moon remain unanswered: Where and how did it originate? Was it torn Eve-like from the side of the earth, or did it form separately out of the same primordial dust cloud? Was it a planetary interloper captured by the earth's gravity when it wandered too close, or did it coalesce from small asteroids in orbit around the ancient earth? Did it ever have an atmosphere? water? life?

Now, after centuries of wondering and theorizing, man is on the threshold of knowing. On the lunar surface, he may at last learn the secrets not only of the moon and its birth but also of the beginnings of his own planet and of the solar system itself.

The Apollo 11 manned landing will begin returning scientific dividends as soon as Astronauts Armstrong and Aldrin start to explore the lunar surface. Both are competent amateur geologists. They have had more than 120 hours

of instruction from NASA geologists, and they have practiced collecting rock and soil samples in lunarlike terrain such as the Grand Canyon, California's Medicine Lake highlands, the Arizona meteorite crater, the arctic wastelands of Iceland, and Alaska's Valley of Ten Thousand Smokes. Even their on-the-spot descriptions of the moon, to be transmitted instantaneously by radio to earth, should be of substantial value.

Other scientific benefits will flow immediately from the instruments that the astronauts will leave behind on the moon. As soon as Astronaut Aldrin sets up a seismometer on the lunar surface, for example, a command radioed from earth will activate it by releasing four suspended weights. In the future, whenever a quake or a meteor disturbs the lunar surface, the seismometer's frame will vibrate, while the suspended weights remain immobile. The seismometer, sensing the relative motion between the frame and the weights, will express it as digital data and transmit it to earth. The instrument is so sensitive that it will even register Astronaut Aldrin's footsteps after he sets it in place and clomps off.

Precise Measuring Rod

The astronauts will also leave behind a laser reflector pointed toward the earth. The reflector actually consists of an array of 100 quartz corner reflectors, so called because they are shaped like the corner of a cube or a room. Each reflector has a valuable characteristic: it will reflect a beam of light directly back to the source. Thus light aimed at the lunar reflector from a laser located in Los Angeles, for instance, will bounce directly back to Los Angeles.

By timing the round trip of the laser beam, scientists will be able to fix the distance between the earth and the moon at any time to within 6 in. of the exact figure. This precise measuring rod should help answer a number of vexing scientific questions. By revealing previously

unmeasurable variations in the orbit of the moon, for example, it should provide a better understanding of the nature of gravity. For if scientists can determine precisely how much the moon's orbit is increasing each year, they may finally be able to confirm—or disprove—the theory that the force of gravity is gradually diminishing.

Using the same distance-measuring technique, with the moon as a reference point, scientists will, during the next several years, also be able to make precise measurements of the wobbling of the earth on its axis. This motion, called Chandler's Wobble, should tend to damp out with the passage of time, but is periodically reinforced by unknown forces—possibly earthquakes. More accurate measurements of the wobble with the aid of the laser reflector might someday lead to a technique for earthquake prediction.

Another terrestrial phenomenon—continental drift—could be confirmed by the lunar laser experiment. Periodically measuring the distance between the moon and lasers beamed from fixed points in Africa and South America, scientists will use triangulation to determine whether the distance between the two continents is gradually increasing.

The astronauts will leave a third item, the solar-wind experiment, on the lunar surface for only two hours or so. Soon after emerging from *Eagle*, they will place on the lunar surface a sheet of aluminum foil suspended from a stand. It will be exposed to the constant stream of particles expelled by the sun and should trap rare gases such as argon, krypton, xenon, neon and helium. Returned to earth in a vacuum box, the captive gases will be analyzed to give scientists new insights into the sun and the "wind" that it blows through the solar system.

Beyond a doubt, however, the most important contribution of Apollo 11 to modern science will be the 100-odd

lbs. of lunar rock and soil scheduled to be brought back by the astronauts. To safeguard this precious cargo, NASA has set up an elaborate system that stretches from the moon across space to Houston's \$15.8 million Lunar Receiving Laboratory (LRL) and to universities and laboratories all over the world. Says LRL Curator Elbert King: "Scientifically, this will be worth more than any other material in history."

Biological Barrier

Elaborate safeguards have been set up to protect the lunar samples from contamination. Should earthly gases and organisms invade the moon rocks before they are thoroughly analyzed, investigators would find it difficult to distinguish between the lunar and terrestrial origins of their samples.

In the safety of their triple-sealed vacuum storage boxes, the lunar samples will be rushed to the LRL even before the Apollo 11 crew members arrive to wait out their 21-day quarantine period. There are "time-critical" tests that must be performed swiftly to detect any gas or radioactivity that the samples may give off; the emissions may decrease or stop soon after the sample is removed from the lunar surface. The samples will be sealed off from the rest of the world by a double biological barrier: 1) a vacuum system and a series of vacuum chambers in which the specimens remain while technicians handle them through insulated "glove ports" or by remote-controlled mechanical arms; and 2) an air-conditioning system that maintains lower air pressure within the LRL than outside so that, if there is a break in the system, air would flow in, keeping lunar matter from leaking out.

The lunar samples will remain under quarantine in the LRL for 45 to 50 days, while 200 NASA scientists and technicians photograph, weigh, catalogue, chip and even burn them. Particles of the samples will be tested on living cells, including those taken from fish and from a human cancer. Other particles will be fed to a variety of earth life, such as Japanese quail, algae, sunflowers, pine seedlings, oysters, white mice and cockroaches—the last chosen because they are one of the hardiest insects known to man, having survived as a distinct genus for millions of years. All the organisms involved were painstakingly bred and raised in germ-free conditions. The mice, for example, were born by caesarean section in sterile surgery and raised in a sterile environment.

If the organisms remain healthy and no other evidence of lunar bugs develops by the end of the quarantine period, samples of lunar rocks will be

sent to 142 "principal investigators" at outside universities and laboratories, chiefly in the U.S. "Some of these men have been waiting for such a chance for 40 years," says LRL Director Persa Bell.

Several groups of the eager investigators have been assigned the job of measuring the age of the lunar specimens by radioactive dating methods. By determining the ratio of radioactive elements (say, rubidium and uranium) in a moon sample to the amounts of their products of decay (strontium and lead, respectively), scientists can make a good approximation of its age. Thus, because the Apollo 11 samples will be taken from the surface of the Sea of Tranquillity, researchers may well be able to estimate the age of the moon's *maria*, or seas. This, in turn, might settle a longstanding controversy among selenologists: Were the *maria* formed as recently as 100 million years ago, or have they existed nearly as long as the moon itself—billions of years?

Perhaps most intriguing is what the moon may reveal about the earth's murky infancy. The earth was formed some 4.5 billion years ago, but the slow, relentless process of its evolution wiped out all traces of its earliest years; the oldest known terrestrial rocks date back about 3.3 billion years. "What has happened during the missing 1.2 billion years?" wonders Astronomer Robert Jastrow, Director of NASA's Goddard Institute for Space Studies in New York. "We do not know; they are a blank page in the history of our planet. If the age of the rocks on the surface of the moon turns out to be 4.5 billion years, we may learn the answer." One of the

most important parts of the answer concerns biogenesis, the beginning of life, which occurred on earth more than three billion years ago.

Some scientists are hoping that unexpected clues in Apollo's samples will lead to new and more satisfying theories about the moon's origin. Complains Astrophysicist Ralph Baldwin: "There is no existing theory that gives a satisfactory explanation of the earth-moon system as we know it." Nobel Laureate Chemist Harold Urey wryly notes that it would be easier to prove that the moon did not exist than to get agreement on how it came to be.

Little Green Bugs

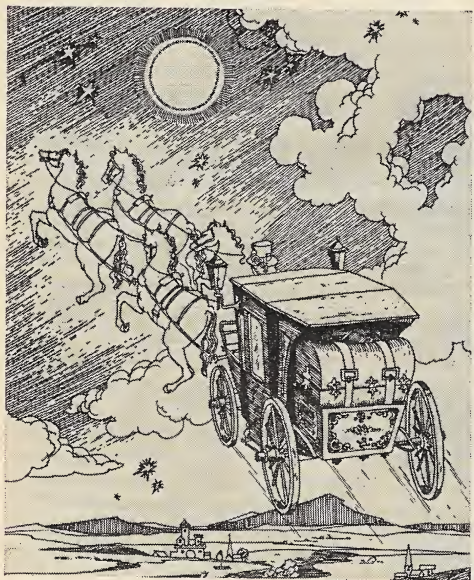
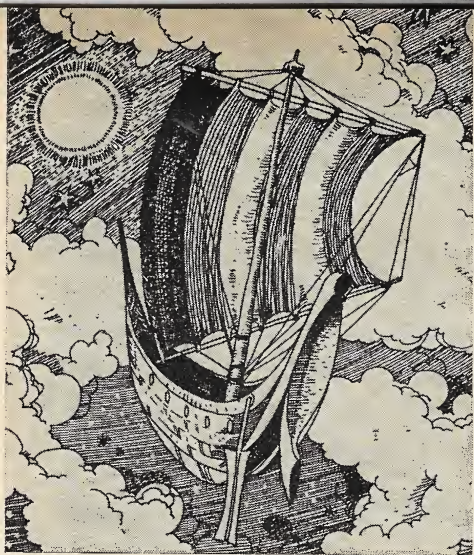
Chemical analysis of the samples may also help determine whether lunar material was ever hot enough to have melted, or whether it has been relatively cool almost from the first. Moon specimens strikingly lacking in volatile elements such as potassium and arsenic could indicate that these substances had been expelled by high temperatures—and would support the theory of a volcanic moon. Those who believe that meteors gave the moon its cratered surface might still argue, however, that the volcanism had occurred only in areas struck—and heated—by huge meteors. Studies of the crystal size and average density of sample rocks will supply other evidence that should go a long way toward proving or disproving the theory that the moon endured an earthlike period of melting, volcanism and slow cooling.

While the geologists, chemists and physicists are busy with their investigations, other scientists will be on an even more exciting quest. Biochemists will be examining the specimens for evidence of amino acids and protein molecules—the building blocks of life. Paleontologists will seek fossil remnants of organisms. At NASA's Ames Research Center at Moffett Field, Calif., still other investigators will try to coax life itself from the lunar rocks, using nutrients in the hope of resuming a life process that might have been interrupted millions of years ago.

In all, investigators will have three months after the quarantine is lifted in which to complete their studies of the material. Soon afterward, there will be a major conference at which papers from all of the participating scientists will be presented. Should there be a major discovery—perhaps even during the preliminary screening of material at the Lunar Receiving Laboratory—NASA is certain to lose no time in announcing the news. "If we find any little green bugs," promises Wilmont Hess, the LRL's science director, "you'll hear about them real quick."



MOON SPECIMEN RECEIVING LAB
Where the past and present are as one.



Dreamed Spacecraft: Transporting men to the moon has never been a problem for poets and visionaries, who have been dreaming about space travel for nearly two millennia. The Syrian satirist Lucian proposed a sailing ship (*top*), the Persian poet Firdausi a throne borne by eagles (*center*), the Italian Renaissance poet Ariosto a coach drawn by four red steeds.

ILLUSTRATIONS FROM "HISTORY OF ROCKETRY & SPACE TRAVEL" BY WERNER VON BRAUN & FREDERICK I. ORDWAY III.

CAN THE MOON

LOOKING down at the pitted surface of the moon from a height of 70 miles last December, Apollo 8 Astronaut Frank Borman described it as "vast, lonely and forbidding—a great expanse of nothing." But looks can be deceiving. As desolate as the moon appears, scientists have little doubt that man will soon work, play, and perhaps even prosper on his bleak satellite.

The environment that makes the moon so hostile to terrestrial life is, paradoxically, precisely what makes the moon so potentially valuable. The absence of atmosphere, which exposes any life on the moon to deadly radiation and the inhospitable vacuum of space, also makes the moon an ideal base for observatories and some industries. Meteors, which have battered the lunar surface for eons have probably also endowed the moon with immense mineral wealth. Although lunar days and nights are each two weeks long and accompanied by deadly extremes of temperature (ranging from 240 degrees Fahrenheit above zero to 250 below), both the unshielded rays of the sun and the numbing cold of the night can be turned to the advantage of human settlers.

A Leisurely Look

Man's early visits to the moon will be largely taken up with exploration and scientific studies of the lunar substance and structure. But man will not long be able to resist making practical use of his closest celestial neighbor. As soon as they are able, for example, astronomers will be competing to book passage to the moon. There, freed at last from the obscuring mantle of terrestrial atmosphere, they will immediately get a clearer, more revealing and more leisurely look at the universe around them.

On the atmosphereless moon, optical telescopes can be used continuously; no clouds, air currents or air pollution can impede viewing. Were the giant, 200-in. optical telescope at Mt. Palomar to be duplicated on the lunar surface, for example, it could observe stars that are 10,000 times too faint for it to detect through the earth's atmosphere.

Because the moon rotates on its axis only about one-thirtieth as fast as the earth, stars move slowly across the lunar skies, making it easier to track and photograph them. Because lunar gravity is only one-sixth the earth's, structural distortions caused by the sheer weight of large telescope mirrors and their supports will be dramatically lessened. Some scientists have estimated that telescope mirrors as large as 2,000 in. in diameter (ten times the earth's largest) could be used effectively on the moon.

The moon has equally great advantages for radio telescopes, which in recent years have greatly expanded the

observable universe, locating quasars and discovering pulsars and other strange celestial objects. Not all radio frequencies can penetrate earth's atmosphere; on the lunar surface, radio telescopes will be able to pick up the entire spectrum of these frequencies. Furthermore, by building radio telescopes on the back side of the moon, astronomers will be able to escape completely from the radio interference caused by earth's increasingly electronic civilization. Without the background "noise" to contend with, radio astronomers will be able to detect much fainter radiation from space, perhaps even the weak signals of a distant civilization.

Unsuspected Galaxies

California Institute of Technology Astronomer Fritz Zwicky believes that observations from the moon will quickly yield answers to two major astronomical problems. With telescopes on the moon, scientists can take more definitive spectrums from the light of remote stars, and perhaps obtain decisive data about the universal "red shift" of light (caused by the speeding outward of distant galaxies). By precisely measuring the shift—and thus the speed of recession—of these galaxies, scientists should be able to determine whether the universe will continue to expand eternally or eventually stop and then begin contracting. "It could settle once and for all the question of the evolution of our universe," Zwicky says, "and give us some understanding of its large-scale structure." In addition, he notes that with a view of the far infrared range, "we shall not only be able to see down to the central nucleus of the Milky Way system, but we may see right through the Milky Way and observe galaxies about which we are not even aware today."

Scientists acknowledge the obvious difficulties and great costs of transporting large telescopes and other heavy equipment to the moon. To obviate the problem, Rand Corp. Researcher George Kocher suggests actually building a large mirror on the lunar surface, using quartz produced from silica—if it exists on the moon—and giving it a more accurate surface than terrestrial mirrors by shaping it with ion beams (which are effective only in a vacuum) instead of abrasives. Several astronomers have pointed out that round lunar craters lined with chicken wire would make ideal reflectors for radio telescopes similar to the 1,000-ft. Cornell University radio dish, set in a rounded valley near Arecibo, Puerto Rico.

The moon is also a natural, orbiting Cape Kennedy. To blast off, a spacecraft need overcome a pull of gravity only one-sixth as strong as the earth's, and does not have to expend any energy to push through a thick atmosphere.

BE OF ANY EARTHLY USE?

Thus an escape velocity of little more than 5,000 m.p.h. (v. 25,000 m.p.h. from earth) and the use of a relatively small amount of fuel will be sufficient to launch moon rockets toward the earth and more distant planets.

Lunar gravity is relatively so weak, as a matter of fact, that some scientists have suggested launching spacecraft by simply accelerating them with electrical power along a track. Unimpeded by atmospheric friction, the vehicles could accelerate very rapidly, limited only by the maximum gravity that their cargo could withstand. An unmanned craft designed to take a force of 50 G's, for example, could reach escape velocity on a track only four miles long. Manned ships, whose passengers could not be exposed to so high a G-force, would need a track considerably longer.

Near Perfect Vacuum

Manufacturers, too, may eventually find the moon economically irresistible. Anywhere they choose to locate on the 15 million square miles of lunar surface, there is a near perfect vacuum—a condition that is obtained on earth only with thick walls and elaborate pumps, and at great expense. As the need grows for "hard" vacuums in industrial processes on earth, the day may come when certain lightweight, easily transportable items that require a vacuum in their production—electronic tubes, computer components, hearing aids—can be made more economically in lunar factories.

Metallurgical research would also benefit from the moon's vacuum, in which pure metals with maximum densities could be produced. Manufacturers who need elaborately protected "clean rooms" on earth for their production processes would find that the moon itself is a huge clean room, with no atmosphere to circulate dust and other contaminants around assembly areas.

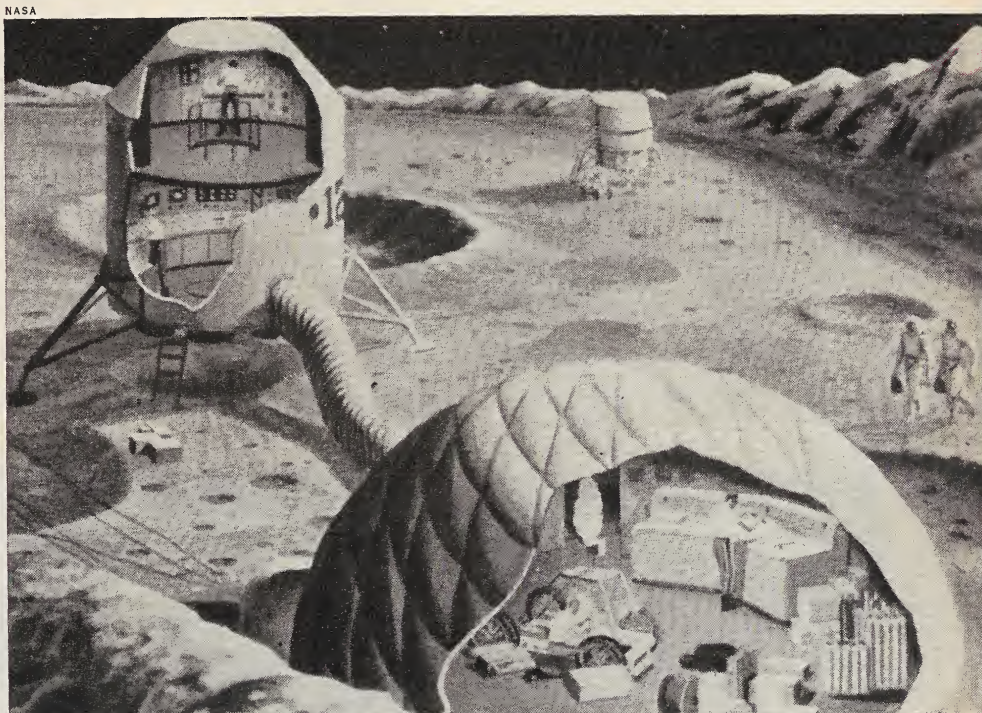
The lunar environment is also ideal for cyclotrons and other devices that accelerate subatomic particles in a vacuum. For the same reason, electron beam-welding—which also requires a high vacuum—would be facilitated on the moon. Another joining process, cold-welding, could become an important part of lunar industry. In a vacuum, two perfectly clean and smooth metal surfaces—uncontaminated by oxides that are formed in the earth's atmosphere—can be welded solidly together without heat and with little pressure.

Even the lunar vacuum itself may some day become a salable commodity. Says *Industrial Research* magazine: "It is conceivable that a simple sealed pressure shell containing literally nothing inside, or an insulated package of a material cooled to -441° F. or lower, with suitable 'vacuum locks,' could be shipped

to earth ports intact—for a price less than evacuation or helium cooling on mother earth."

Valuable as the moon's vacuum may be, there are more palpable treasures. Some scientists, assuming that the moon was created when the earth was, some 4.5 billion years ago, calculate that about 10 trillion tons of meteors have fallen on the lunar surface. From their analysis of the composition of the relatively few meteors that reach the earth's surface (most are burned up by the atmosphere), they estimate that meteors

furnaces could be constructed, consisting of mirrors that focus the sun's fierce beams on a target. Using these, Zwicky suggests, man could work wonders with lunar rock. The furnaces could melt lunar gravel and soil, which could be cast into bricks for building shelters. They could also be used to heat moon rocks enough to release their locked-in water. Even the proverbial pig's squeal could be used. Water vapor steaming out of the heated rocks could drive power turbines before being condensed into drinking water. When lunar water is finally avail-



ARTIST'S CONCEPTION OF A MOON BASE IN 1975

What makes it so hostile is what makes it so potentially valuable.

have deposited 450 billion tons of iron, 30 billion tons of nickel, 10 billion tons of phosphorous, 9 billion tons of carbon, 6 billion tons of copper and 3 billion tons of cobalt on or near the lunar surface. If their figures are correct, the meteor fall would also have contributed 300 billion tons of carbonaceous chondrites, containing about 30 billion tons of water chemically locked in crystals with other compounds.

These vast resources are important not only for their potential use on earth, but also for their value in making a lunar colony self-sufficient. Although engineers hope eventually to reduce the cost of shipping payloads to the moon by using simple, unsophisticated boosters and flyable stages that can be returned to earth and used again, it now costs \$22,187 per lb. with Saturn 5. The key to tapping lunar resources, Zwicky believes, is energy from the sun, which beats down directly on the moon's surface, unfiltered by atmosphere. Solar

able in ample supply, it could even be used for rocket fuel. Moon technicians will decompose it into hydrogen and oxygen gases by electrolysis, then feed the gases into a lunar cryostat, a device that can reach extremely low temperatures during the chill lunar night without using power. The resulting products would be liquid hydrogen and liquid oxygen, familiar space-age fuels.

Zwicky would also produce carbon dioxide by focusing the rays of a solar furnace on rocks containing calcium carbonate. The carbon dioxide would be released into the atmosphere of a covered garden to sustain green algae living in a tank of water. The rapidly reproducing algae would not only be an excellent source of protein for humans on the moon but would also produce vitally needed oxygen as a by-product of photosynthesis.

Astronomer I. M. Levitt, director of the Fels Planetarium of Philadelphia's Franklin Institute, believes that colo-

nizers of the moon will eventually produce their own water, a contained atmosphere, food and other necessities completely from lunar materials. He envisages vegetables grown from seed, rooted in tanks of water in which the necessary lunar minerals have been dissolved. His moon colonies, complete with farm animals and factories, launch pads and lunar surface vehicles, and the comforts of home, would be located underground—in sealed-off caves and domes—to protect inhabitants against meteors, solar radiation and the extremes of lunar temperatures.

Nor would the inhabitants want for luxuries. Levitt believes that virtually anything man—or woman—might desire can be produced on the moon by combining available minerals with a source of energy to produce chemical reactions. One of Levitt's chemical chains, beginning with carbon and calcium, can lead to the manufacture of medicines, plastics, dyes, food additives, rubber, ceramics, even fertilizers and textiles. "Naturally, we're going to insist that the girls go with us to the moon," grins Levitt, "and when we get there we'll be able to make all of their lipsticks, perfumes, nail polishes—you name it."

An advocate of moon colonies for

20 years, Levitt is no mere dreamer. To help prove his point, he has actually built a working model of a solar still. Using four 20-in. mirrors, he focuses sunlight on powdered pitchstone in a glass laboratory tube until its water of crystallization steams off. The steam is then channeled to an adjacent model still, where it is converted to drops of water.

Lunar Vacations

NASA Administrator Thomas Paine is so confident of continued progress in space flight and the establishment of lunar bases that he foresees vacations on the moon within two decades that will cost the affluent thrill seeker as little as \$5,000—round trip. "There is no question," Paine says, "that we can reduce the cost of travel to the moon to the cost of traveling through the air today. The spacecraft we use will be descendants of today's Boeing 707s and Douglas DC-8s, married to today's hydrogen-oxygen rockets."

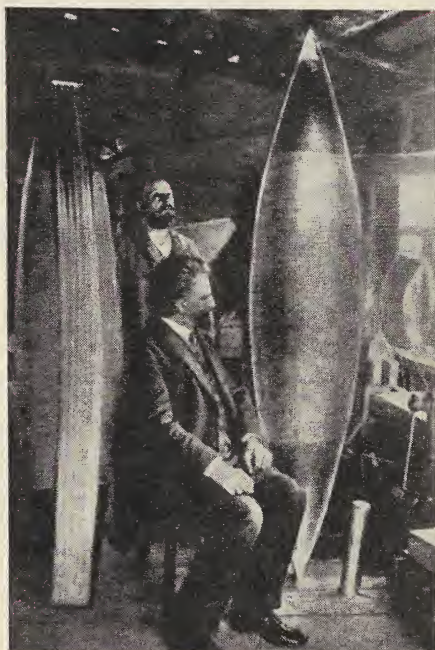
For the price, the vacationer will enjoy some exhilarating experiences in the weak lunar gravity. On a diving board, for example, he will be able to spring six times as high as on earth. When the splash occurs, it will be a veritable gey-

ser, also six times as high as on earth. Even more remarkable, a visitor to a domed lunar resort will be able to don a pair of wings and flap off like Icarus into the artificial atmosphere, using only muscle power to fly.

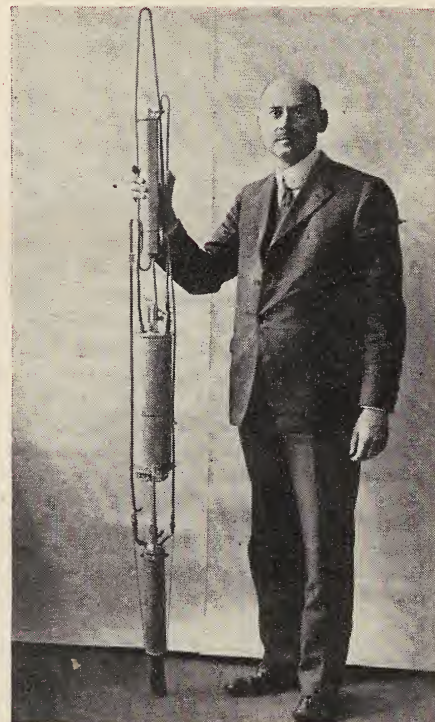
Though such notions about the uses of the moon may sound visionary, they are tame alongside some of the really futuristic ideas. A Russian has suggested covering the entire side of the moon that is visible to earth with a reflectant coating to make it a huge thermal power plant. Zwicky theorizes that man may one day actually be able to shrink the moon through nuclear fusion; a smaller, denser moon would have greater gravitational pull, perhaps enough to hold a habitable atmosphere. Levitt speculates that in the distant future the moon may serve as a launching platform for a 1,000,000-ton spaceship (Apollo 11's weight at lift-off: 3,200 tons), an intergalactic Noah's ark that could carry a complete civilization to nearby stars.

Ridiculous? No more so than the visions of Jules Verne and H. G. Wells seemed less than a century ago. Given the remarkable feats already achieved by technology, it would be unwise to bet against almost any possibility.

THE PIONEERS



CULVER PICTURES



ESTHER C. GODDARD

RUSSIA'S Konstantin Eduardovitch Tsiolkovsky (left) never built a rocket, but by 1898 he had worked out the basic principles of rocket dynamics. America's Robert Hutchings Goddard (right) launched the world's first liquid-fuel rocket in 1926 and patented 214 devices and parts, most of them essential to the operation of modern rocket engines. Germany's Hermann Oberth (center) popularized the idea of space travel as a real possibility in his 1923 bestseller *The Rocket into Planetary Space*, and his writing helped inspire Germany to early prominence in the field.

Tsiolkovsky and Goddard are dead. Oberth, now 75 and living quietly near Nürnberg on a meager pension, has mixed feelings now that his lifelong dream is about to come true. "Sometimes I feel like an unmusical person who attends a concert and doesn't really understand what seems to excite everybody," he says. "On other occasions I feel like a mother goose who has hatched a brood and now, somewhat perplexed, watches the flock going off into the water. It is only very rarely that I have the satisfaction that everybody believes I ought to feel."

THE CREW: MEN APART

RALPH MORSE—LIFE



ARMSTRONG & FAMILY
Right out of Rockwell.

IF they accomplish their mission, the three men assigned to pilot *Columbia* and *Eagle* to the moon will rank with history's most illustrious explorers. Yet each realizes that the privilege—and the peril—of making man's first lunar landing belongs to them only by an unlikely combination of luck and circumstance. Edwin ("Buzz") Aldrin, 39, who will steer the lunar module to the surface of the moon, puts it this way: "We've been given a tremendous responsibility by the twists and turns of fate."

Command Pilot Neil Armstrong, 38, could have missed his destiny as the result of half a dozen close shaves. He crashed his Panther jet behind enemy lines in Korea, but escaped a day later. As a civilian test pilot in 1962, he plummeted uncontrollably toward earth when the rocket engine in his X-15 failed to start, but it caught on just in time. As commander of Gemini 8 in 1966, he had to abort the scheduled three-day flight after ten hours when a short circuit threw the spacecraft's thrusters out of control. Last summer he had to eject from a lunar-landing research vehicle at an altitude of only 100 ft. when it spun out of control and crashed.

Buzz Aldrin might not have been an astronaut at all but for his persistence, raw determination—and good fortune. He was turned down when he first applied in 1962. Though he was a veteran fighter pilot (two MIGs destroyed, one damaged in 66 Korean missions for the Air Force), NASA regulations at the time demanded that astronauts be graduate test pilots. The next year, after the regulations had been eased to let in combat pilots with more than

1,000 hours of experience flying jets, Aldrin was accepted.

Michael Collins, 38, owes his couch on the moonship to a bout of bad health. He was to have been a member of the Apollo 8 crew, which made man's first orbits around the moon last Christmas. A paralyzing bone spur in the neck sent Collins to the hospital in June 1968 for a risky operation, however, and Bill Anders took his place. The surgery was a complete success, and Collins was back on full flight status by last November. It was much too late for him to resume his original place with the Apollo 8 crew—but it opened the way for him to join Apollo 11.

Stick and Rudder Men

The members of Apollo 11's crew are seasoned, imperturbable astronauts. Armstrong, known as an inscrutable loner, flew Gemini 8 to the first successful space docking. Aldrin, a hard-driving perfectionist, set the record for space walking (5 hr., 30 min.) during the four-day flight of Gemini 12 in 1966. Collins, the most relaxed and outgoing of the three, helped steer Gemini 10 through complicated rendezvous and docking maneuvers.

As a team, they are remarkably free from quarrels, but they are not close friends. They waste few words on the job, generally talking to each other in technological jargon. Once in a while, Mike Collins cracks a joke. Once in a longer while, Neil Armstrong flashes a fleeting smile. After work, they go their separate ways. It may be true, Aldrin admits, that they have all been somewhat

RALPH MORSE—LIFE



COLLINS AT HOME
Master of the dry style.

dehumanized by what he calls "the treadmill" of the space program.

Dehumanized or not, the crew fully measures up to Boss Astronaut Donald K. ("Deke") Slayton's tough requirements. "You're really looking for a damn good engineering test pilot," says Slayton. "They've got to be good stick and rudder men, and also real smart." Not many qualify. Of 1,400 applicants for the last batch of astronauts in 1967, only eleven were chosen. There are now only 49 astronauts and, in many ways, all are as precise as the laws of celestial mechanics—and as unforgiving as the machines that hurtle them through space. Says Slayton of his astronauts: "They don't have any technical weaknesses. If they did, we wouldn't have them aboard."

Like so much else at NASA, the selection of the moon-landing crew seemed totally routine. Indeed, when the crew was selected in January, there was no assurance that Apollo 11 would make the first moon landing. Apollo 10 was then still a candidate for the mission; there was also the distinct possibility that if problems developed, the attempt would be postponed until Apollo 12, 13 or even 14. "There isn't any big magic selection that goes on for each mission," says Slayton, whose crew recommendations have never been overruled. "It is like every squadron of fighter pilots. You've got a mission to do and you've got so many flights to fly and you assign guys to fly them. It's that straightforward."

Command Pilot Armstrong is considered tight-lipped and phlegmatic, even in the notoriously taciturn fraternity of

LEE BALTERMAN—LIFE



ALDRIN & WIFE
Blood brothers on the team.

HOW IT WAS MANAGED

WHEN John F. Kennedy committed the U.S. to landing men on the moon before the end of this decade, virtually none of the equipment capable of making the half-million-mile journey existed. Now, eight years later, a great spaceship made of more than 15 million parts is poised for the flight. If Apollo 11 completes its momentous mission, Kennedy's pledge will have been redeemed with five months to spare—a remarkable accomplishment. It is all the more remarkable for the fact that man did not actually enter the space age until twelve years ago, when the Russians launched Sputnik.

The U.S. space program was truly embryonic when Kennedy, on May 25, 1961, set a lunar landing as the nation's goal. Only two months earlier, he had decided to put off a decision on whether to go ahead with the Apollo program. Then came Cosmonaut Yuri Gagarin's orbital flight, the first ever made by man. Two days after the Soviet breakthrough, Kennedy convened the nation's top space experts at the White House. "If somebody can just tell me how to catch up," he said. "There is nothing more important."

Neither, it seemed, was there anything more difficult. Before Kennedy made his moon-landing announcement, the nation's entire manned space experience totaled 15 min. 20 sec.—the length of Alan Shepard's suborbital fling down the Atlantic test range on May 5, 1961. Rockets had been blowing up on their Cape Canaveral launch pads with humiliating frequency; from 1958 to 1964, the U.S. suffered 13 straight failures in its efforts to send rockets around or onto the moon.

Most discouraging of all was the estimate that more than 10,000 separate tasks would have to be performed before the U.S. could put a man on the moon. James Webb, administrator of the National Aeronautics and Space Administration between 1961 and 1968, compared the problem to "having to take a caterpillar and make it into a butterfly when we had never seen a butterfly."

That the butterfly now exists is, above all, a tribute to superb management techniques. This was the biggest and most imaginative Government-industry-university team ever put together for a single project. At its peak in 1966, Apollo involved 400,000 men and women at 120 universities and laboratories and 20,000 industrial firms; its budget for that year alone was \$5.9 billion.

In building the team, NASA all but threw away the rule book. It was clear, for example, that university brains would have to be tapped. But instead of following the usual practice of giving Government scholarships directly to stu-

dents, and allowing the students to shop for berths at a few Ivy League universities, NASA turned the money (\$100 million so far) over to a large number of universities, thus ensuring greater cross-fertilization of ideas.

NASA took a similar tack toward American industry. At the outset, General Electric approached NASA with a proposal that it be awarded a single massive contract covering the entire program. The agency demurred. For one thing, space officials feared that a single contractor might at times decide to manufacture a part or system itself rather than buy it elsewhere. For another, the officials reasoned that a fruitful exchange of technology would occur if many companies were involved. Accordingly, NASA selected 16 prime contractors, who, in turn, have assigned work to tens of thousands of subcontractors. The firms range in size from North American Rockwell, which has 105,000 employees and builds the giant Saturn 5, to the Space Electronics Supply Co. of Melbourne, Fla., a two-man operation that makes fuse holders for Apollo.

When fire killed Astronauts Gus Grissom, Ed White and Roger Chaffee on the launch pad during a routine test in 1967, the trauma rocked the space agency at every level. Work stopped, tempers flared and accusations flew. The attempt to land on the moon was set back at least a year. But the tragedy spurred NASA to tighten up operations and to fashion a mechanism that has performed almost flawlessly ever since.

For every dollar now spent on designing and manufacturing Apollo parts, another dollar is spent testing them. Before an Apollo vehicle is approved for flight, it is tested, probed, checked and rechecked for four months; no fewer than 25,000 pages of procedures cover the painstaking process. "One of the keys to success," says Rocco A. Petrone, 43, director of the Apollo launch operations, "is the quality testing that the program has taken to the *n*th degree."

Such unrelenting attention to the most microscopic detail carries right through the missions. The astronauts themselves carry 40 lbs. of documents aboard the spacecraft—flight plans, check lists, manuals and so on. While they are aloft, a NASA team keeps track, day and night, of nearly 40,000 key people in the contractor network. Thus, should a tiny valve go awry during a mission, an official at a console in Houston can pick up a telephone at any hour and discuss the problem with the man who designed the part. Says Lieut. General Samuel Phillips, manager of the Apollo program, "We tattoo responsibility on a man's head." Even so, the members of the NASA team have not forgotten how to cross their fingers.

astronauts. "Silence is a Neil Armstrong answer," his wife Janet said in an interview with LIFE. "The word no is an argument." Last spring, he spent two full days with his father and never once bothered to mention that the day after they parted he was going to be officially named as the first man to set foot on the moon. With his sandy hair, innocent blue eyes and boyish smile, he looks as though he has just stepped out of a Norman Rockwell painting. More than any other astronaut, Neil Armstrong epitomizes small-town America.

He was born in Wapakoneta, Ohio (pop. 7,500), the son of a career civil servant who is now assistant director of the state's Department of Mental Hygiene and Correction. As a youth, Neil limited his social life mainly to school and church functions; when he went out with a girl it was usually on a double date to the ice-cream parlor. He played baritone horn in the school band. He studied hard, and while his teachers do not remember Armstrong as a particularly brilliant student, he impressed them all with the thorough, meticulous way he went about his work. Says Professor Paul E. Stanley, who taught Neil aerodynamics at Purdue: "He was a Boy Scout [in fact, he made Eagle Scout at 17], and he literally lived up to the motto 'Be Prepared.'"

Faith in Machines

Armstrong first set eyes on an airplane at the age of two, and he made his first flight at six in an old Ford trimotor. As a boy, he was forever assembling model airplanes, and while other youngsters were still scrambling for comic books, he went right for the aeronautical publications when the magazine shipments arrived on the stands. He worked part time in the drugstore (40¢ an hour) and as a grease monkey at the airfield to accumulate the money for flying lessons (\$9 an hour), and earned his pilot's license on his 16th birthday, the first day he was eligible. For a while, he had to bicycle the three miles between Wapakoneta and the field; Neil Armstrong was flying planes before he had a driver's license.

At about the same time, the future astronaut was taking his first close look at the moon through a homemade 8-in. reflector telescope fashioned from a stovepipe and mounted on roller-skate wheels atop a garage. The wondrous device belonged to Jacob Zint, a neighbor of the Armstrongs and a draftsman in the Westinghouse plant. "I can't recall that Neil ever said he wanted to go to the moon," says Zint. But as early as 1946, Armstrong was regularly visiting the makeshift observatory and often, says Zint, "he looked right into the Sea of Tranquility"—the prime site for next week's landing.

After graduating from Wapakoneta High School, Armstrong won a Navy scholarship to Purdue, the alma mater of three other astronauts (Gus Grissom and Roger Chaffee, both of whom died

in the Apollo launch-pad fire of Jan. 27, 1967, and Eugene Cernan, a member of the Apollo 10 crew). Called to service in Korea at the end of his sophomore year, Armstrong earned a reputation as a hot pilot and three Air Medals in 78 combat missions. Returning to Purdue, he collected his degree in aeronautical engineering, and a wife, the former Janet E. Shearon of Evanston, Ill., who was studying home economics at Purdue when they met. They have two sons: Eric, 12, and Mark, 6.

A Lot of Marbles

Armstrong went to work for NASA as a civilian test pilot for the X-15 rocket plane, which he flew at 3,989 m.p.h. and an altitude of 207,500 ft.—both records at the time. In the early days of the space program, Armstrong had no desire to become an astronaut. Says a close acquaintance: "He thought those guys were playing around with a lot of marbles." After the "marbles" began lifting other pilots into space, he changed his mind and in 1962 became one of the second group of astronauts to be chosen. As a civilian, he is paid more than any other astronaut (\$30,054 a year, v. Aldrin's \$22,650 as an Air Force colonel and Collins' \$20,400 as an Air Force lieutenant colonel), a fact that has stirred resentment. There are men in the space program, in fact, who detect behind Armstrong's supercool all-American image a rigid character who has more faith in the perfectibility of machines than of people. "He's all scrubbed up on the outside," says a NASA official, "but inside he has nothing but contempt for the rest of mankind that isn't willing to work as hard as he does."

Dr. Charles Berry, the astronauts' flight surgeon, differs. "Neil strikes some people as cold," admits Berry, "but that is partly bashfulness. He is really warm and blushes easily." Yet, says Stanley Butchart, who tested planes with Armstrong and now directs flight operations for NASA at Edwards Air Force Base, Calif., "I think you could know him for a long time and not really know him." A friend who has been in Armstrong's house dozens of times agrees: "For all I know, he could be a secret poet or a secret sadist."

Air Force Colonel Buzz Aldrin, who will guide the lunar module and step onto the moon's surface after Armstrong, is also something of an introvert. His future seems to have been ordained even before his birth in affluent Montclair, N.J. His father, Edwin Sr., was a noted aviator in the 1920s, and is the man who introduced Charles Lindbergh to America's greatest rocket pioneer, Robert Goddard. As a result of the meeting, Lindbergh arranged a \$50,000 Guggenheim grant for Goddard, which allowed the inventor to move to New Mexico to develop the rocketry that would one day carry Aldrin's son to the moon. For what it is worth, the maiden name of Buzz Aldrin's mother was Moon.

WHO MADE IT POSSIBLE

IF teamwork and a sense of shared responsibility were crucial factors in the U.S. effort to land men on the moon, so were the contributions made by a number of individuals. By providing the answers to such questions as how to build a big enough booster, what flight plan to follow, and how to guide the spacecraft, these men eliminated obstacles that might have delayed the program indefinitely. Among the men:

► Dr. John C. Houbolt, 50, former chief of theoretical mechanics at NASA's Langley Research Laboratories in Hampton, Va. Houbolt, a civil engineer, is responsible for the lunar-orbit rendezvous that is the key maneuver in Apollo's entire flight plan. In what he remembers as "an intuitive flash," Houbolt realized that tremendous weight

man, has been the driving force behind the moon program.

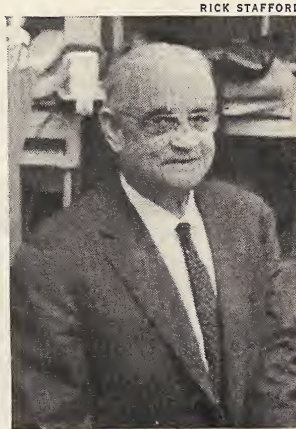
► Dr. Charles Stark Draper, 67, director of the Instrumentation Laboratory at the Massachusetts Institute of Technology. To solve the problems of navigation, NASA went straight to the nation's leading authority on inertial guidance. The system devised by Draper for Apollo includes telescopes, a sextant, and a computerized inertial reference "platform" that tells astronauts where they are in space, where they are headed and how fast. But how could they be sure that it would work?, the NASA brass wanted to know. "I told them I'd go along and run it myself," recalls Draper. The on-board navigation systems have proved so accurate that, if they had to, the crew of *Columbia*



HOUBOLT



VON BRAUN



DRAPER

savings would be gained by this rendezvous method, permitting the use of a smaller launch vehicle. Often scorned by colleagues, Houbolt fought a two-year battle, finally put his job on the line by appealing directly to NASA headquarters. His arguments prevailed in the fall of 1962.

► Dr. Wernher von Braun, 57, director of the Marshall Spaceflight Center in Huntsville, Ala. Transported to the U.S. by American intelligence officials in 1945, along with 126 other German scientists who had been working on the V-2 rocket at the Baltic base of Peenemünde, Von Braun has directed development of rocket-launch vehicles from the earliest Redstone. Von Braun helped develop the ablative heat shield, which dissipates the searing heat of reentry by flaking off in harmless fiery pieces. His Huntsville group can also claim credit for what has become known in the space agency as "cluster's last stand"—the grouping of several smaller rockets in a cluster to provide as much thrust as would a single, far larger rocket engine. Saturn 5's first stage, for example, uses five F-1 engines, each generating 1,500,000 lbs. of thrust. Von Braun, perhaps more than any other

could fly to the moon and back without help from ground controllers.

Other men were almost as indispensable. Maxime A. Faget, director of engineering and development at Houston's Manned Spaceflight Center, designed Apollo's command and service module. Dr. George E. Mueller, NASA's top official for manned spaceflight, introduced a time-saving technique known as "all-up testing," in which all three rocket stages are tested together. Christopher Columbus Kraft, director of flight operations since 1961, and George Low, manager of the Apollo program, brought a sense of cool discipline to the nerve-racking operations in Houston.

Then, too, there is Donald K. ("Deke") Slayton, the man who selects and trains the astronauts. The professionalism of the Apollo crews is a reflection of Slayton's success—but leaves him less than totally fulfilled. Though he was chosen as one of the original seven U.S. astronauts in 1959, a mild heart murmur prevented him from ever venturing into space. When he was asked recently what he would best like to be remembered for, Slayton replied: "As the pilot of Apollo 11." There was no smile on his craggy face.

While Aldrin has always been known as a devoted team player, a quality essential to the success of manned missions, he is also very much his own man. He was, for example, the only astronaut to take part in Houston's Palm Sunday memorial march for Martin Luther King last year, and he did so without asking anybody in NASA for permission. "It was something I wanted to do," he says simply—and he says no more about it. The episode is in keeping with some advice he gave home-town well-wishers in New Jersey a few years ago. "Just so much can be done on a formal team," he said. "A vast amount of preparation for life must be done on an individual basis."

Aldrin is also exceptional among astronauts in being able to claim an important contribution to the theory of space flight. His doctoral dissertation at the Massachusetts Institute of Technology dealt with the question of orbital rendezvous. The ground was so new and Aldrin's approach so original that some of his professors had difficulty understanding him. The doctoral committee, according to rumor, accepted his thesis with reservations. NASA had no reservations, and no trouble understanding Aldrin's language. A copy of the thesis found its way to the space agency during the early stages of the Gemini project, and NASA scientists were borrowing ideas from it even before Aldrin had joined the program.

Calculated Risks

A brilliant, almost straight-A student throughout his years in the Montclair public school system, Aldrin went on to West Point, where he finished third in a class of 475. After combat duty in Korea, he was assigned to the U.S. Air Force Academy as aide to the dean of the faculty, then flew fighters in West Germany. He began thinking about joining the space program, but decided that he needed more education. After getting his doctorate from M.I.T. in 1963—46 years after his father had received his bachelor's degree there—Aldrin was selected for the third group of astronauts. He is married to the former Joan Archer of Ho-Ho-Kus, N.J. They have three children: Michael, 13, Janice, almost 12, and Andrew J., just 11.

Athletics have always been all-important to Aldrin. Recollects Albert Hartman, the boy's primary-school principal: "He was willing to take risks, but when he took one you had a pretty good feeling he knew what he was doing. When he decided to steal in baseball, his judgment was usually on the winning side." As center on the Montclair High School football team, he com-

pensated for his smallness (5 ft. 10 in., 165 lbs.) with ferocity, and helped lead the team to its first league championship in 15 years. Those who played with him recall Aldrin's strong team loyalty. Says former Montclair Footballer Ted Cox Jr.: "This was big business with Buzz. You were blood brothers with him if you were playing football."

Air Force Lieut. Colonel Mike Collins, who will orbit the moon in the command module while Armstrong and Al-



PLAQUE TO BE PLACED AFTER LANDING

Man must go where he can.

drin land and return from the surface, is by all accounts the most likable member of the crew. Though he comes from a distinguished military family, he goes out of his way to slop around in jeans and act as unmilitary as possible. He enjoys cooking gourmet dinners and knows his way around French wines. To Collins, everybody is "Babe," and he likes to poke fun at the bloated titles that the simplest pieces of space hardware carry. "What we need in the space program is more English majors," he says.

He was born in Rome, where his father, Major General James L. Collins, was military attaché, and he grew up in Puerto Rico and Washington, D.C. After attending St. Albans, a prep school in Washington, he went to West Point, excelling in soccer, wrestling and tennis, and finishing 216th in the class of 1952, a year after Aldrin. Not even Collins' closest friends at the academy knew until senior year that he was the nephew of General J. Lawton ("Lightning Joe") Collins, famed World War II commander of the 25th ("Tropic Lightning") Division on Guadalcanal, leader of the breakthrough at St.-Lô after the Normandy invasion, and later Army Chief of Staff.

If Mike Collins was fired by any particular ambition in his early years, he managed to conceal the fact. Even as a test pilot, and a member of a traditionally no-nonsense profession, he remained relaxed and easygoing. "He lived from day to day and didn't care too much about the future," recalls Bill

Dana, a classmate of Collins' at West Point and a fellow test pilot at Edwards Air Force Base. Adds Dana: "He didn't really take hold until he got into the space program." That happened in 1963 when NASA accepted his application to be an astronaut. Collins is married to the former Patricia Finnegan of Boston. They have three children: Kathleen, 10, Ann, 7, and Michael Jr., 6.

Collins is a master of the dry style of humor that is characteristic of many of the astronauts. How did his wife feel about his latest and most hazardous space assignment? Replied Collins: "She gets a little bit happier every time. However, I think she's reached a peak in happiness now, and I'm going to just leave her right where she is." He is also the most philosophical member of the crew, especially about his own motives for venturing into space. "I really think the key is that man has always gone where he could, and he must continue," Collins said. "He would lose something terribly important by having that option and not taking it."

Men Apart

The Apollo 11 crew has been in full-time training since January, spending 12-hr. days often seven days a week going over and over the 294-page flight plan, rehearsing every move they will make in flight simulators, checking and re-checking the command module and lunar module. They practiced a single maneuver—the powered descent to the lunar surface—at least 150 times. Flight Surgeon Berry was seriously concerned about their grueling schedule. He feared that the men might become so tired that their resistance to disease would be dangerously low and that they would catch the flu or one of the gastrointestinal disturbances that afflicted three of the previous four Apollo crews. If that happens, says Berry, "I'll have the whole world on my back demanding proof that they are not down with some moon bug." Berry publicly discouraged Richard Nixon from dining with the astronauts on the eve of their flight, lest the President pass on germs. When the crew members made their final pre-launch public appearance at a press briefing in Houston eleven days before lift-off, they entered the room wearing rubber masks to cover their mouths and noses and sat within a tentlike glass canopy. Both precautions were designed to reduce the risk of infection.

In a way, the barrier that set Armstrong, Aldrin and Collins apart from their questioners was highly appropriate. When—if all goes well—the three make their next public appearance, they will do so as mankind's first voyagers to an extraterrestrial body. They are only men, chosen for their role by fate as well as by their own unquestionable talents. But by virtue of their momentous experience, they will also be men set apart from their fellows.

BEYOND THE MOON: NO END

Few men have written about space with greater foresight and intelligence than Britain's Arthur C. Clarke. Now 51, and living in Ceylon, Clarke has published 40 books of science fact and fiction, including 2001: A Space Odyssey. In 1945, he made the first proposal for the orbiting of a synchronous communications satellite. In 1959, he made—and has just narrowly lost—a bet that man would land on the moon by June 1969. Here, at TIME's request, Clarke weighs the consequences of man's first extraterrestrial venture.

NOT long ago, a critic of the space program suggested that as soon as the first astronauts came safely back from the moon, we should wind up manned flight and leave exploration entirely to robots. This may well rank as the silliest statement of a notably silly decade; to match it one must imagine Columbus saying: "Well, boys, there's land on the horizon—now let's go home."

Manned operations will be vital for the development of space industry. Even if—as is likely—most of the satellites for communications, meteorological, earth survey and other purposes will be automatic devices, we shall need human crews to install and service them.

Log-Canoe Stage

The moon is only the first milestone on the road to the stars. The exploration of space—by man and machine, for each complements the other—will be a continuing process with countless goals, but no final end. When our grandchildren look back at earth, they will find it incredible that anyone there failed to realize so obvious a fact of life.

Today's space technology, for all its glittering hardware, is still in the log-canoe stage. The next decade, therefore, despite all the spectacular achievements

it will surely bring, will be a period of consolidation. Such a technological plateau occurred in 1945-55, when the results of wartime rocket research had to be assimilated before the first breakthrough into space was possible. We are now entering a very similar period; some time after 1985, the true space age will begin to dawn.

In our present state of almost total ignorance, the only prediction that can be safely made about the other eight planets and their 30-odd moons is that there is not a single one upon which unprotected men can live. Most of these places are almost unimaginably alien; but that very fact will give them immense scientific value. Moreover, in a very short time—historically speaking—we may be forced to exploit resources beyond the earth. This may become necessary or desirable even if, as seems probable, great progress is made in the production of synthetics and in exploiting the resources of the sea.

Planetary Garbage Dump

This does not give us a charter to continue turning earth into a planetary garbage dump; in an ecological sense, we must put our own house into order before we expand into others. But it is good to know that they are there—even though extensive alterations will be required to make them comfortable. Our generation has learned how to kill a world; the same powers can bring life to worlds that have never known it.

The history of technology teaches us that the right tool always arrives at the right time; witness how the transistor was ready when the space age dawned. The cycle may be beginning again, leading to feats of astronomical engineering as inconceivable to us as televising would have been to the Victorians. Whatever technologies the future may bring, the

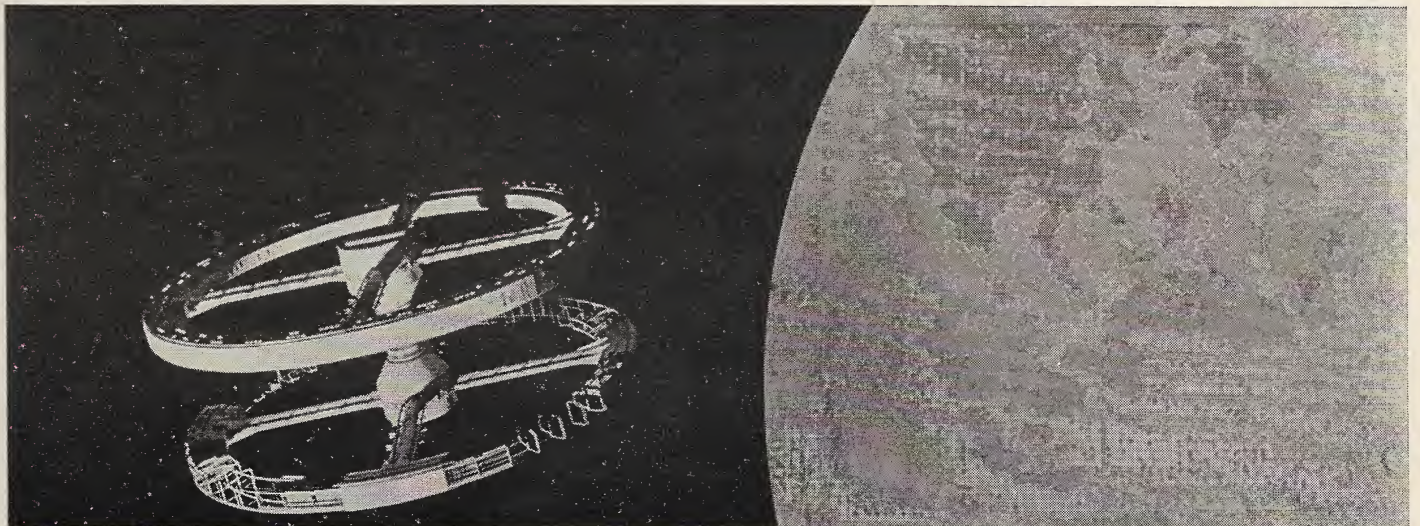
doors of heaven are now opening; this is the central fact of our age.

Those who are—understandably—obsessed with the urgent problems of today, aim at the wrong target when they attack the space program. They say the money would be better spent on the ghettos or the hungry, especially with so much already going to the Viet Nam war. That the money would in fact be spent in such a way is, at best, debatable. Moreover, cost effectiveness is not a criticism that can or should be applied to advanced technology. Who would have put money on atomic energy in 1940? A nation which concentrates on the present will have no future; in statesmanship, as in everyday life, wisdom lies in the right division of resources between today's demands and tomorrow's needs.

The Real Promise

There is always the fear, of course, that men will carry the curse of their animosities into space. But it is more likely that in the long run, those who go out to the stars will leave behind the barriers of nation and race that divide them now. There is a hopeful symbolism in the fact that flags will not wave in a vacuum; our present tribal conflicts cannot be sustained in the hostile environment of space. Whether we like it or not, our children will find new loyalties when they set foot on the moon, or Mars, or the satellites of the giant planets. They did so in these United States a hundred years ago; they will do so on the United Planets in the centuries to come.

And this is the real promise of space exploration—the reason why it appeals so strongly to the young in heart. The Frontier, which only a generation ago seemed lost forever, is open again. And this time it will never close.



SPACE STATION IN MOVIE "2001"
Only the first milestone on the road to the stars.